PINNA NOBILIS AND EPIPHYTIC FORAMINIFERA AS POTENTIAL BIOINDICATORS OF HEAVY METAL POLLUTION IN BALEARIC ISLANDS (WESTERN MEDITERRANEAN)

M. Morató Trobat [1]*, A. Khokhlova [2], S. Deudero [1], G. Mateu-Vicens [2], M. Vázquez-Luis [1] and J. Campillo [3]
[1] Centro Oceanográfico de Baleares-IEO - merce.morato@ba.ieo.es
[2] Cátedra "Guillem Colom Casasnovas", Universidad de las Islas Baleares
[3] Centro Oceanográfico de Murcia-IEO

Abstract
Metal (Cd, Cu, Hg, Pb, and Zn) concentrations and percentage of deformed foraminifera were measured in soft tissues of *P. nobilis* and sediment samples, respectively, in order to assess pollution levels in Baleraric Islands.
Analyses of Cabrera and Mallorca indicated that heavy metal concentrations were generally higher in the majority of samples, specially in Santa Maria bay (Cabrera, MPA), where high percentages of deformed shells (up to 26 %) and high values of metal pollution index (38.171 mg/Kg) were found.

Keywords: Balearic Islands, Bio-indicators, Bivalves, Foraminifera, Metals

Introduction
Heavy metals are an special group of contaminants, being the most common environmental pollutants and can be either adsorbed onto sediments or accumulated in benthic organisms, sometimes to toxic levels [1].
Pinna nobilis L., 1758 is a fan mussel endemic to the Mediterranean Sea and is considered the biggest bivalve mollusc of this area. It is common within the seagrass meadows of *P. oceanica*,is a long-lived species, benthic filter and easy to find at the seabottom. Foraminifera are protozoans with an external skeleton (shell), forming one of the most conspicuous groups in the epiphytic community of the *P. oceanica*. Foraminifers are very abundant in all marine environments, they have relatively short life-cycles and they react quickly to environmental changes at global and a local scale, are highly adapted to well-defined ranges of environmental parameters and pollution. Analysis of soft tissues of endemic bivalve *Pinna nobilis* revealed high heavy metals levels. The analysis of foraminifera assemblages revealed considerable amounts of individuals with deformed shells. These organisms are known as being significant bioindicators for monitoring seagrass meadows ecosystems, therefore their specific response to environmental changes can indicate the presence of the pollutants [2].

Materials and methods
The study area comprehends four localities from the Balearic Islands, situated in Mallorca (Andratx and Magaluf) and Cabrera (Santa Maria bay and Els Estels - only foraminifera samples). Mallorca is the biggest island of the Balearic Islands, which is located in the Western Mediterranean. The study area is located in the southern part of the island, two stations, Magaluf and Andraxt, with different degrees of anthropic impact was investigated and the other stations, Santa Maria bay and Els Estels (only foraminifera samples) were observed in Cabrera island (9 km south-east of Mallorca) which is characterise by the excellent conditions with low anthropogenic impact, and has the maximum degree of protection since 1991(LAW 14/1991).
Fourteen *P. nobilis* samples were taken in October 2011 by scuba diving and samples of foraminifera were collected over soft bottoms colonized by *P. oceanica* from May to November 2012 in the same sites. Concentrations of Cd, Cu, Pb and Zn were determined by atomic absorption spectrometry (AAS), and Hg was determined by Advanced Mercury Analyzer (AMA 254). For comparison of total metals at the sampling sites, the metal pollution index (MPI) was applied ([3]; [4]).

Results and discussion
Species identification and morphometric analyses of benthic foraminifera revealed high percentages of deformed shells, from 7% in Andratx, to the highest value in Santa Maria Bay (up to 26%) where only 1% of deformed shells in natural population can by present. Metal Pollution Index (MPI) mean concentrations in soft tissues of *P. nobilis* samples (dry weight) range from 6.22 mg/Kg in Andratx, 34.45 mg/Kg in Magaluf, and 38.17 mg/Kg in Santa Maria bay.

Higher values of heavy metals agree the highest percentages of deformed foraminifera, thus MPI and percentage of deformed foraminifera reaches the maximal value in Santa Maria bay and the minimal value in Andratx. The metal pollution index reaches the maximal value for Santa Maria Bay can be explained by the fact that the highest concentrations of three metals (Cd, Pb and Zn) out of the five considered.

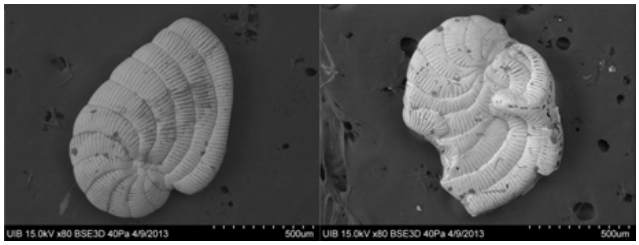

Fig. 1. Normal and deformed foraminifera *Peneroplis planatus* from Cabrera, Balearic Islands.

Conclusions
The high percentage of abnormal tests and metal pollution index indicates the presence of heavy metal pollution higher in Cabrera, marine protected area. Generally, the most effective bio-monitoring approach is to use several species representing differing trophic levels [5]. Therefore, the use of these organisms as bioindicators can be very useful in determining the health of seagrass meadows ecosystems in areas that have no obvious symptoms of degradation.
Assessing bioaccumulation is also a component of international efforts to identify and control chemicals of environmental concern, and there is a need to establish reliable procedures for estimating bioaccumulation potential from knowledge of properties of the substance.

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